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▶ To cite this version:

Hong Nam Nguyen, Minh Ha-Duong, Laurent van de Steene. A critical look at rice husk gasification in Cambodia: Technology and sustainability. International Forum on Green Technology and Management (IFGTM) 2015, Jul 2015, Hue, Vietnam. hal-01150079

HAL Id: hal-01150079

https://hal.science/hal-01150079

Submitted on 8 May 2015

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A CRITICAL LOOK AT RICE HUSK GASIFICATION IN CAMBODIA: TECHNOLOGY AND SUSTAINABILITY

Nguyen Hong Nam[1], Ha-Duong Minh[1,2*], Laurent Van De Steene[1,3]

8 May 2015

[1]Department of Renewable Energies, University of Science and Technology of Hanoi, Vietnam
[2] The international research center on environment and development, National Center for Scientific Research, France
[3] The Agricultural Research Centre for International Development, France

[*]*Email:* minh.haduong@gmail.com

ABSTRACT

In recent years, many Cambodian enterprises have installed rice husk gasifiers to substitute diesel in the electricity production to run rice mills machinery, or to provide electricity for villages. This study provides a critical look at rice husk gasification by assessing the sustainability of deploying this technology in Cambodia, expressed through environmental, economic and social impacts, and evaluates if it can be applied in Vietnam. Results show that gasification technology works in Cambodia and contribute to the development of the rice-milling sector, however environmental issues are severe and should be treated. We observe that increase in rice husk demand also leads to increase in price of rice husk, therefore new investors should consider the effect of new rice husk market for their activities. We conclude that this technology would not be suitable for Vietnam and suggests studying other alternative technologies to convert rice husk into energy, such as steam engine or steam turbine, gasifier stove, briquetting or co-firing.
Keywords: biomass, gasification, rice husk, Cambodia.

RESUME

Au cours des dernières années, de nombreuses entreprises cambodgiennes ont installé des gazéificateurs de balle de riz pour substituer le diesel dans la production d'électricité pour faire fonctionner la machinerie dans les rizeries, ou pour fournir de l'électricité pour les villages. Cette étude fournit un regard critique sur la gazéification de balles de riz par l'évaluation de la durabilité du déploiement de cette technologie au Cambodge, exprimée à travers les impacts environnementaux, économiques et sociaux, et évalue si elle peut être appliquée au Vietnam. Les résultats montrent que la gazéification fonctionne au Cambodge et contribue au développement du secteur des rizeries, cependant les problèmes environnementaux sont graves et devraient être traités. Nous observons que l'augmentation de la demande de balles de riz conduit également à une augmentation dans le prix de la balle de riz, donc les nouveaux investisseurs devraient considérer l'effet du nouveau marché de la balle de riz pour leurs activités. Nous concluons que cette technologie ne serait pas appropriée pour le Vietnam et suggère d'étudier d'autres technologies alternatives pour convertir la balle de riz en énergie, tels que le moteur à vapeur ou la turbine à vapeur, le réchaud domestique à gazéification, briquettes de balles de riz ou la co-combustion.

Mots-clés: biomasse, gazéification, balles de riz, Cambodge.

1. INTRODUCTION

In 2014, the total rice production in Cambodia was approximately 9.3 million tons. Rice husk accounted for approximately 20% of paddy production on a weight basis, meaning that 2 million tons of rice husk were produced. Only 10% of rice husk in Cambodia is utilized as fuel for household cooking and for brick kilns [1]. Rice mills have to throw the rest away or burn it out as a way of disposal. This creates environmental hazard and air pollution for the surroundings.

Electricity price in Cambodia is among the highest in the region due to limited domestic fossil fuel resources. The state-owned electricity provider Electricité du Cambodia (EDC) provides electricity with cheapest tariffs, from \$0.09 to \$0.25 per kilowatt-hour (kWh), but only 25% of Cambodians are having access to EDC grid. Other domestic suppliers use diesel as fuel and supply electricity at a tariff between \$0.75 and \$1 per kWh [1]. This has led Cambodians living in areas without access to the EDC grid to try new technologies to produce electricity at a lower cost.

Since 2003, scores of rice Cambodian mills and Rural Electricity Enterprises (REEs) have installed rice husk gasifiers (RHGs) to substitute diesel in the electricity production. Gasification is a thermochemical conversion process that converts biomass into a carbon monoxide and hydrogen rich-gas called synthesis gas, or syngas. Syngas can be utilized to produce heat, electricity or fuel transportation. Some different generic types of gasifiers have been demonstrated or developed for the conversion of biomass feedstock, namely fixed bed, fluidized, entrained flow and muti-stage gasifier [2]. Previous researches showed that rice husk has great potential for the electricity production using gasification technology in Cambodia [2, 3].

Is a similar development possible in Vietnam, which compares to Cambodia in term of rice husk production and utilization? Each year 8 million tons of rice husk are produced in Vietnam, of which 2 million tons still remain unused [4]. Is this kind of gasification an efficient technology to reuse this agricultural waste and convert rice husk into energy to meet the energy demands of the country? How does it compare to other ways of using rice husk for heat and electricity? Our study aims to provide a critical look at the rice husk gasification in Cambodia by assessing its sustainability, expressed through environmental, economic and social impacts and to evaluate if this technology is also appropriate for Vietnam.

2. MATERIALS AND METHODS

In addition to desk research on rice husk gasification, we conducted a field trip to Cambodia in December 2014 [1]. Four rice mills, a REE and a rice husk power plant in Phnompenh, Siem Reap, Battambang and Kompong Thom were selected for the field trip. The rice mills were selected based on the difference of processing capacity: from micro (milling capacity inferior or equal to 1 ton per hour), small (between 1 and 3 ton per hour), medium (between 3 and 10 ton per hour) to big scale (superior to 10 ton per hour), and on the presence of RHGs.

The REE was selected based on the presence of an imported RHG. The power plant selected is the Cambodia's first power plant using 100% RHG to supply power to the local grid. This selection was designed in order to gather diverse types of information on the actual Cambodian rice milling sector and the actual status of RHGs.
Face-to-face interviews with stakeholders (n=24) of RHG projects during the visit were also conducted. Informants included rice mill owners, gasifier users, experts from the non-governmental organization (NGO) SNV Netherlands in Cambodia, representatives of the Canadia Bank and the Federation Cambodian Rice Millers Association. Information obtained through interviews were then screened and classified by social, economic and environmental aspects regarding gasification system, and were verified with experts working on the field of biomass gasification.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Social impacts

Current status of RHGs shows that this technology works in Cambodia. As of June 2014, 116 RHGs were installed in 12 provinces of Cambodia [5]. Most of RHGs are built either within a rice mill or located closed to rice mills. Among them, 104 RHGs were installed by rice mills, 4 by ice factories, 6 by REEs, 1 by garment factory and 1 by brick factory. Battambang has most enterprises invested in RHGs, in comparison with other provinces. All RHGs installed in Cambodia are downdraft fixed-bed gasifiers with capacity range from 100 kW thermal to 750 kW thermal.
The technology has been transferred in two ways: formally and informally. Formally, RHGs of Ankur Scientific Energy Ltd., a leading gasifier manufacturer based in India, are being imported by SME Renewable Energy Ltd. SME installed the first RHG in Cambodia in 2003. As of July 2014, the company had sold 37 RHGs. NGOs such as SNV also organize workshops to train users on operation and maintenance of RHGs, and to produce spare parts locally at more affordable costs. Informally, there are at least five local manufacturers competing with the Indian manufacturer Ankur. The most important local manufacturers are Nou Chanrith with 17 RHGs, Chea Keo with 11 RHGs and Leang Thorn with 6 RHGs sold from 2005 to 2014 [5]. They have copied products of Ankur without license, and provided RHGs at a half price compared to imported systems. However, they do not provide any written technical or safety guideline of RHG systems to their customers.

3.1.2. Environmental impacts

With that technology, one liter of diesel fuel can be replaced by approximately 6 kilograms of rice husk. In Cambodia, RHGs typically allow to substitute for 50% to 75% of diesel fuel used in the electricity production. According to the Intergovernmental Panel on Climate Change rates, one liter of diesel emits 3.16 kilograms of CO_2 equivalent. Two million tons of rice husks, the order of magnitude of the resource in Cambodia and Vietnam, amount to a potential saving of 350 thousand liters of diesel, equivalent to 1.1 million tons of CO_2 emissions. Emissions from rice husk generation activities such as rice cultivation, paddy collection and transportation should be accounted for, notwithstanding the fact that it is a fatal product of rice production. To this date we are not aware of any life cycle analysis for RHGs in the literature.

Liquid wastes produced by RHGs include wastewater and tar. Wastewater is produced when cooling and cleaning the syngas. We observed that it was discharged into the surrounding environment with little treatment in most cases. Laboratory measurements conducted by SNV in 2012 showed a high level of pollution in these effluents [6]. Contents in metals were higher than Maximum Permissible Limits (MPL) for manganese, lead, iron, chromium, copper, arsenic and zinc. High concentrations of other toxic and carcinogenic compounds such as benzene, toluene, ethyl-benzene, xylene (BTEX) and Polycyclic aromatic hydrocarbon (PAH) compounds were also found. Very few users had an idea about the amount of tar produced by RHGs; some reported that tar quantity varied from 0.8 to 10 liters per day. Tar was generally thrown away or burned in some cases. BTEX and PAH compounds are also present in tar at far higher concentrations than MPL [6].

Gaseous emissions from RHGs include CO, CO_2 and water vapor [6]. However, we did not find any published assessment of the quantity of gaseous emissions in Cambodian RHG and any evaluation of their impacts on environment and human health.

Solid wastes from RHGs are mainly rice husk ash, also called biochar. Gasification process produces a large amount of ashes, about 20% of rice husk weight [7]. Ash is generally clean and not harmful for humans [7], however it is bulky and must be disposed of. 85% of rice husk ash produced by RHGs remained unused, 6% were sold off and 9% were given away to villagers with free of charge [5]. There is no major market for ashes in Cambodia; only some rice mills can sell them at a price between \$3 and \$10 to the brick industry or to farmers who use it as soil amendment.

3.1.3. Economic impacts

RHGs have a payback period from 1.5 to 4 years and produce electricity at a cost from \$0.1 to \$0.25 per kWh. This is cheaper than the tariff of domestic suppliers and can compete with EDC price, as long as the rice husk input is free. This was the case up to a few years ago. Rice husk was a waste from rice mills that the owners should pay farmers to come and pick up for disposal. But it is now becoming a commodity. The survey by SNV in 2014 showed that rice mills could sell more than a half (56%) of the amount of rice husk produced, 33% were burned with RHGs inside the rice mill, and only 11% were given away [5]. For example the owner of a rice husk power plant we visited, SOMA Group, buy rice husks at \$5 per ton from rice mills in Kampong Thom. In Battambang, Banteay Meanchey and Pursat, we observed rice husk being exported to Thailand, at market prices around \$3 to \$4 per ton (excluding cost for loading, sack and transportation).

In 2014, 43 RHGs have been shut down and 28 enterprises have switched from RHGs to national grid connection. Besides grid connection, the main reasons to stop using RHGs are difficulties in operation, maintenance, waste management issues and ceasing business altogether. The rice-milling sector is concentrating. Many traditional family-run or village-scale rice mills loose their customers to larger, modern mills with more efficient equipment. Other micro and small rice mills are reconsidering their strategy: they only focus on local market and/or sell paddy for bigger mills. Investing in a new gasifier capacity is hardly an option for them.

3.2. Summary and discussion

The development of RHGs in Cambodia occurred at a time of rapid change in the rice-milling sector. For rice mills using rice husk available on the site, producing electricity using RHGs was cheaper than using 100% fuel or buying from a rural electricity enterprise. Yet the technology is not fully locally controlled since research and development activities are mostly carried out by NGOs and not by local institutions or government. With respect to the environment, RHGs can substitute diesel consumption in the electricity production, hence reduce the CO_2 emissions; but wastes are often not treated in an appropriate way; the current technology treatment seems under-performing; and the potential of biochar/rice husk ash as a soil amendment remains to be demonstrated. The higher rice husk demand causes volatility in feedstock supply and increases the operations and management costs of gasifiers. The example of Thailand is instructive: the price of rice husk increased from $8 per ton when the technology was introduced to $60 per ton in 2014 [8]. This dramatic increase was beyond many investors' expectations and risk tolerance, leading to failure of many gasification projects. Other potential buyers in the same area may also create competition and drive up the cost of rice husk and hence lower the profitability of investors in gasifiers.

We believe that following the same technological trajectory as Cambodia for gasifiers is not a relevant option for Vietnam, since 99.8% people are connected to the national electricity grid with an average tariff of $0.08 per kWh [9], much cheaper than in Cambodia. Moreover, Vietnam has stricter environmental laws and regulations imposing polluters to pay a high environmental tax. The capacity of rice mills in Vietnam is also much bigger than in Cambodia, from 30 tons to 500 tons per day [10], therefore small-scale RHGs would not be suitable for many rice mills.

For these reasons, gasification as done in Cambodia appears to us unlikely to succeed in the Vietnam market. Other technologies to convert rice husk into energy include: steam engine, steam turbine, gasifier stove, briquetting or co-firing. Briquetting of rice husk can be considered for its economics, reliability and ease of operation. Some market of rice husk briquettes for breweries, garment and beverage factories are being formed recently in Vietnam, promising a good sight for the development of this technology [4]. Co-firing of rice husk with coal has been tested and demonstrated in all boiler types commonly used by electric utilities. Co-firing at low rates can often be done with minimal changes to plant handling and processing equipment, requiring little capital investment. According to the "National power development plan for the 2011-2020 period" of Vietnam, coal-fired power will account for 48% of the total capacity of 75000 MW in 2020, the potential of biomass co-firing is therefore great. Gasifier stove is also a suitable option for farmers in rural areas. In Vietnam, 80% of population is living in rural areas, in which 70% of them are using traditional stoves to cook daily [11]. These stoves emit lot of toxic pollutants and seriously affect users' health and their living environment. Local manufacturers and research institutions are developing some types of gasifier stove [12]. A market analysis for domestic gasifier stove is highly recommended to introduce them to people in rural areas. Finally, rice husk based co-generation system could be an alternative for rice mills. Rice husk is burned in a furnace to produce steam in a boiler. The steam is used to run a steam engine or a steam turbine, which, in turn, drives an electric generator. The financial feasibility of the investment in a husk-fuelled steam engine or steam turbine system which drives grid-connected electrical generators have been studied previously [13, 14]. Installation of rice husk fuelled boilers with steam engines and steam turbines would be feasible at small scale and medium/big scale respectively.

4. CONCLUSIONS

Rice husk gasification technology is used in Cambodia since 2003 in off-grid rural areas where rice husk is a readily available agricultural waste. Electrification in many villages of

Cambodia was realized with small-scale downdraft RHGs. These systems substitute more than 50% of diesel consumption in the electricity production for rice mills machineries as well as providing electricity to villages at better costs. Most of RHGs are damaging the local environment, we expect long-term effect of the wastes produced on human health and local ecosystems. Increase in rice husk demand has led to an increase in price of rice husk, which new investors should consider – this hold for any kind of waste re-use technology. Although Vietnam compares to Cambodia in terms of rice husk availability and usage, we believe that adopting the rice husk gasification technology developed there would not be appropriate for Vietnam. Other alternative technologies such as steam engine or steam turbine, gasifier stove, briquetting or co-firing, are recommended for further research to convert rice husk into energy in Vietnam.

Acknowledgements. *We are grateful to the SNV Netherlands in Cambodia and the Federation of Rice Millers' Association for providing very helpful information and feedback. NHN and HDM collected the data, NHN wrote the report and the initial manuscript, LVDS reviewed the report, HDM supervised the research.*

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